

BALLOON FLIGHT VALIDATION OF ARES, AN ATMOSPHERIC ELECTRICITY INSTRUMENT PROPOSED FOR THE EXOMARS-GEP.

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All balloon experiments were launched by CNES.

Brazil: AIRS-HIBISCUS from Bauru, SP, 16 and 24th, 2004 and PEASMA from Timon, MA, December 2d, 2004.

Niger: HVAIRS from Niamey during the AMMA campaign, August 2006

Scope of ARES

The Atmospheric Relaxation and Electric Field sensor (ARES) experiment on the Geophysical and Environmental Package (GEP) of the EXOMARS mission is devoted to the investigation of atmospheric electric phenomena on Mars and elements of a possible global atmospheric electric circuit.

Main topics:

- dust charging and transport, electrical breakdown in the atmosphere
- effects of electric fields in atmosphere-dust-surface physical and chemical interactions
- electromagnetic background environment
- charging of landers, vehicles and habitats

Balloon tests

Balloon tests in the terrestrial atmosphere are the best way for validating the instruments:

- pressure at high altitude ~as on Mars surface
- conductivity in the range of expected martian conductivity (the instrument does not work at ground level on Earth due to an extremely low conductivity)
- possibility to test interferences with other instruments and Solar Arrays.

Scientific Objectives (1) : Global circuit elements

▪ Electrical Properties of the Martian environment.

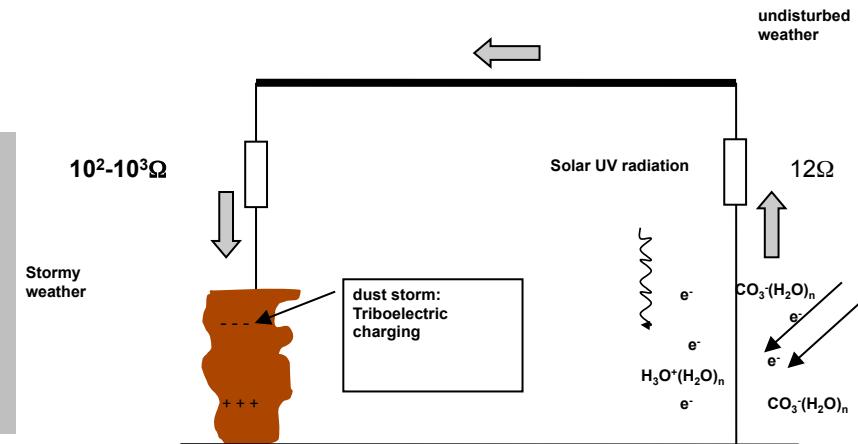
- ionisation of atmospheric constituents by cosmic rays, solar X rays and UV, photo-electrons and micro-meteorites.
- near surface atmosphere electrical conductivity: 10^{-11} to 10^{-10} S/m
- ground conductivity: unknown, 10^{-12} - 10^{-7} S/m
- ionosphere conductivity: > 1 S/m at 120 km altitude

▪ Charging and charge separation mechanisms

- photo-electron emission
- dust impacts

Major unknowns to be studied:

- atmospheric conductivity
- electric fields and charging generators
- electrical breakdown



Global electric circuit of Mars, from Aplin, 2000

Scientific Objectives (2) :

Dust devils and dust storms as generators

Estimations of DC electric field from model
(Farell and Delsh,2001):

Storm regions:

$E \sim 475 \text{ V/m}$ at ground level

Without storms, only dust devils:

$E \sim 0.14 \text{ V/m}$ at ground level

Increase at ground due to photoelectrons:

10-100 mV/m (Grard)

The questions:

Electric Field Buildup and consequences

- Dust lifting and dust transport
- Atmosphere Chemistry
- Physics and Chemistry of surface materials
- Electric discharges

DC electric fields shall be measured in a wide range of amplitudes

Scientific Objectives (3) : EM waves and cavity resonances

Shumann resonances

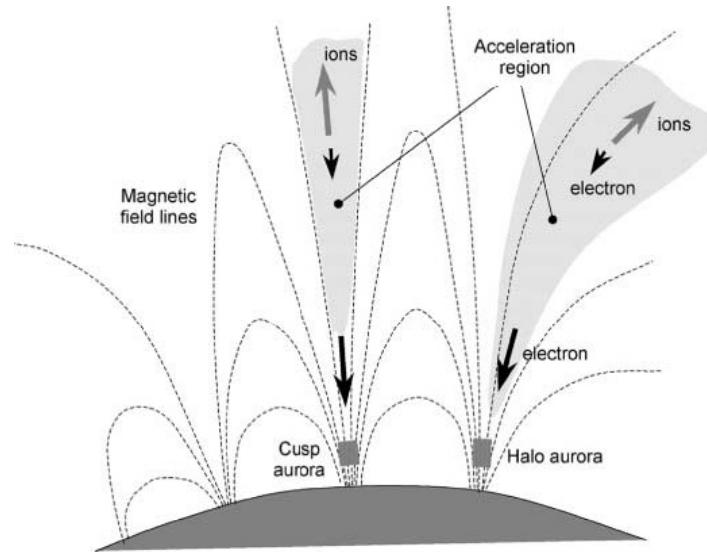
Resonances frequencies (high ground conductivity model):

$f_1 \sim 13\text{-}14 \text{ Hz}$

$f_2 \sim 24\text{-}26 \text{ Hz}$

$f_3 \sim 35\text{-}38 \text{ Hz}$

- the resonance frequencies and Q factors reflect planetary scale ground conductivity
- expected sources:
 - dust devils
 - hydromagnetic waves from upper atmosphere
 - plasma processes in the distant ionized environment and due to solar wind interction.

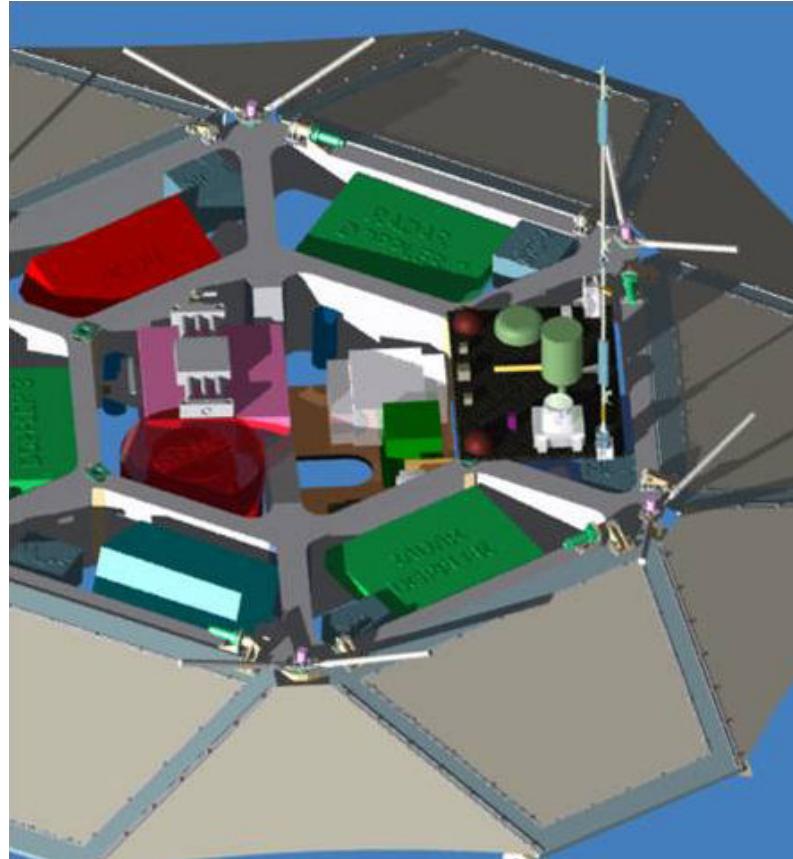


« Small scale » magnetospheres interaction regions

AC electric fields to be measured in a wide range of frequencies and amplitudes

ARES: INSTRUMENT DESCRIPTION

- **2 cylindrical sensors**
 - length 10 cm, diameter 3 cm
 - mounted on an insulated boom at $\sim 60\text{-}100$ cm distance
- **1 electronic card** installed in the "warm" main unit
 - **analog part** to maintain the electrodes at the local floating potential, amplify and filter the quasi-DC and AC signals
 - **digital part** based on a DSP which monitor the instrument, digitalize, process, compress and format the data



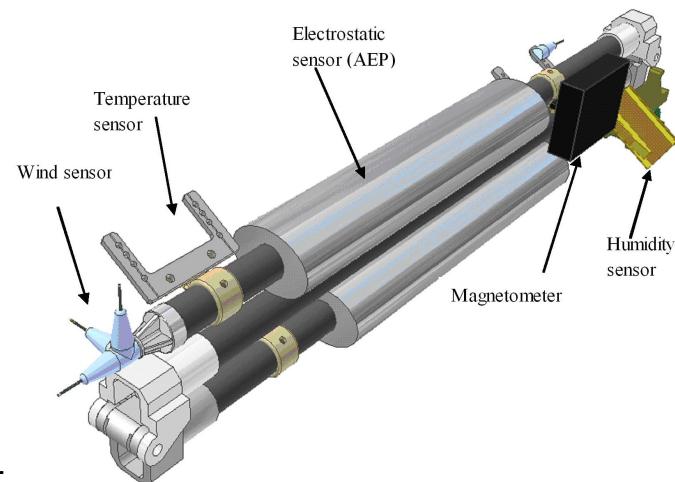
INSTRUMENT SPECIFICATIONS

- Large signals from
 - Small signals in AC from
 - Low electrode voltage ranges
 - High electrode voltage range
 - Specific function
-
- Power consumption
 - Weight
 - Volume



DC to 2 KHz
few Hz to 4 kHz
+ - 50V and + - 120V
+ - 10 kV
Conductivity

143 (160) mW
147 (165) g (120 + 27)
110 × 95 × 15 mm



The balloon tests

Netlander

Bauru, SP, Brazil, 2004



Timon, MA, Brazil, 2004



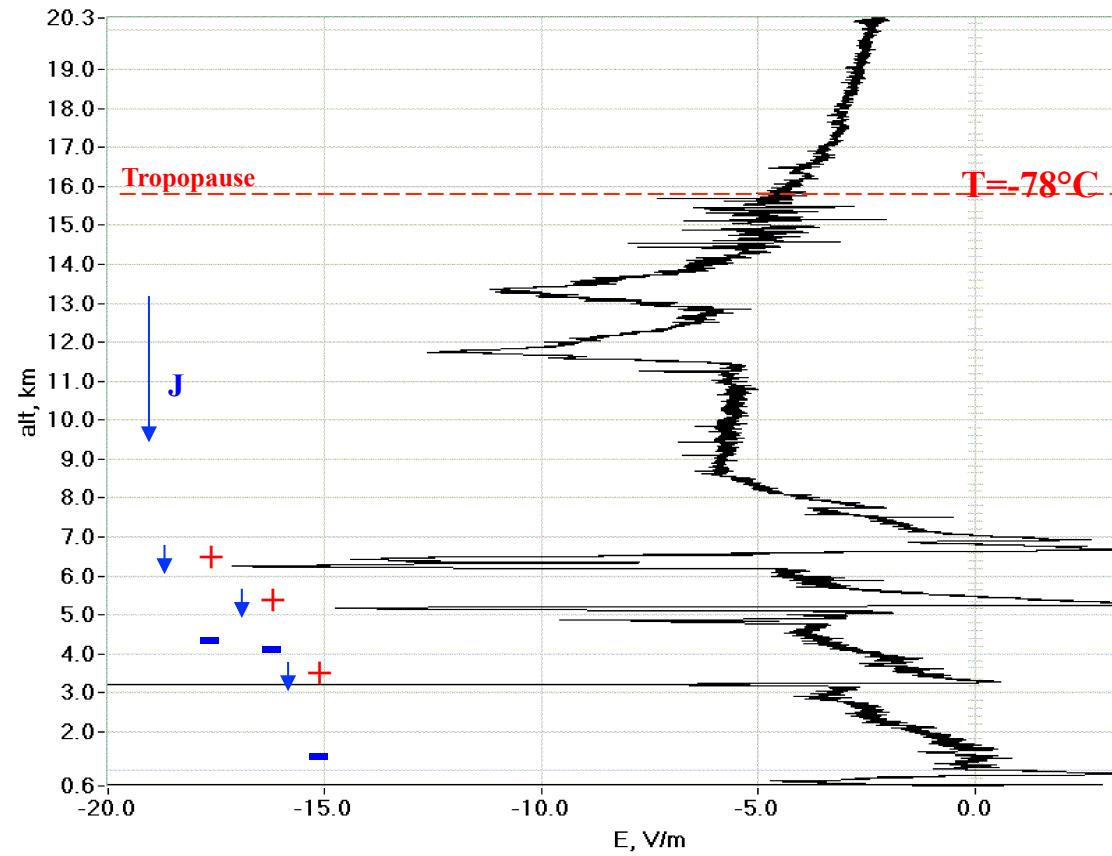
Niamey, Niger, 2006



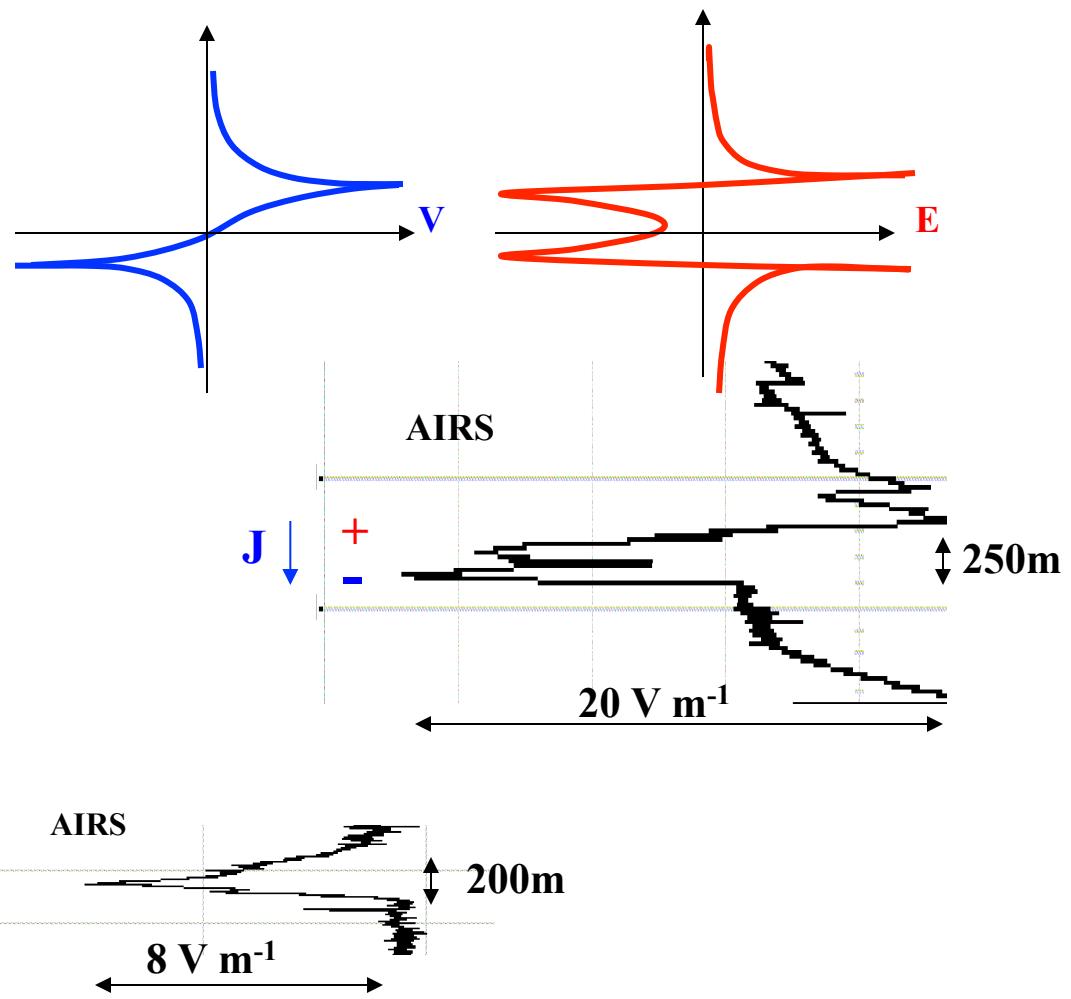
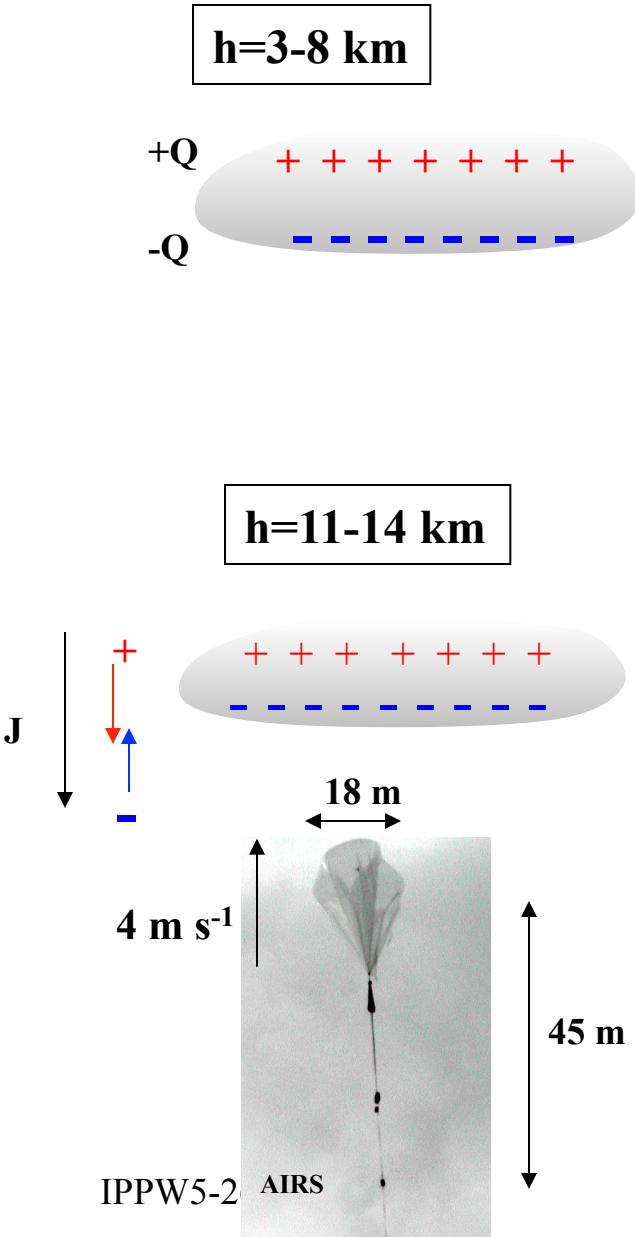
High Voltage
capability

EXOMARS

DC ELECTRIC FIELD MEASUREMENTS (AIRS, Bauru)

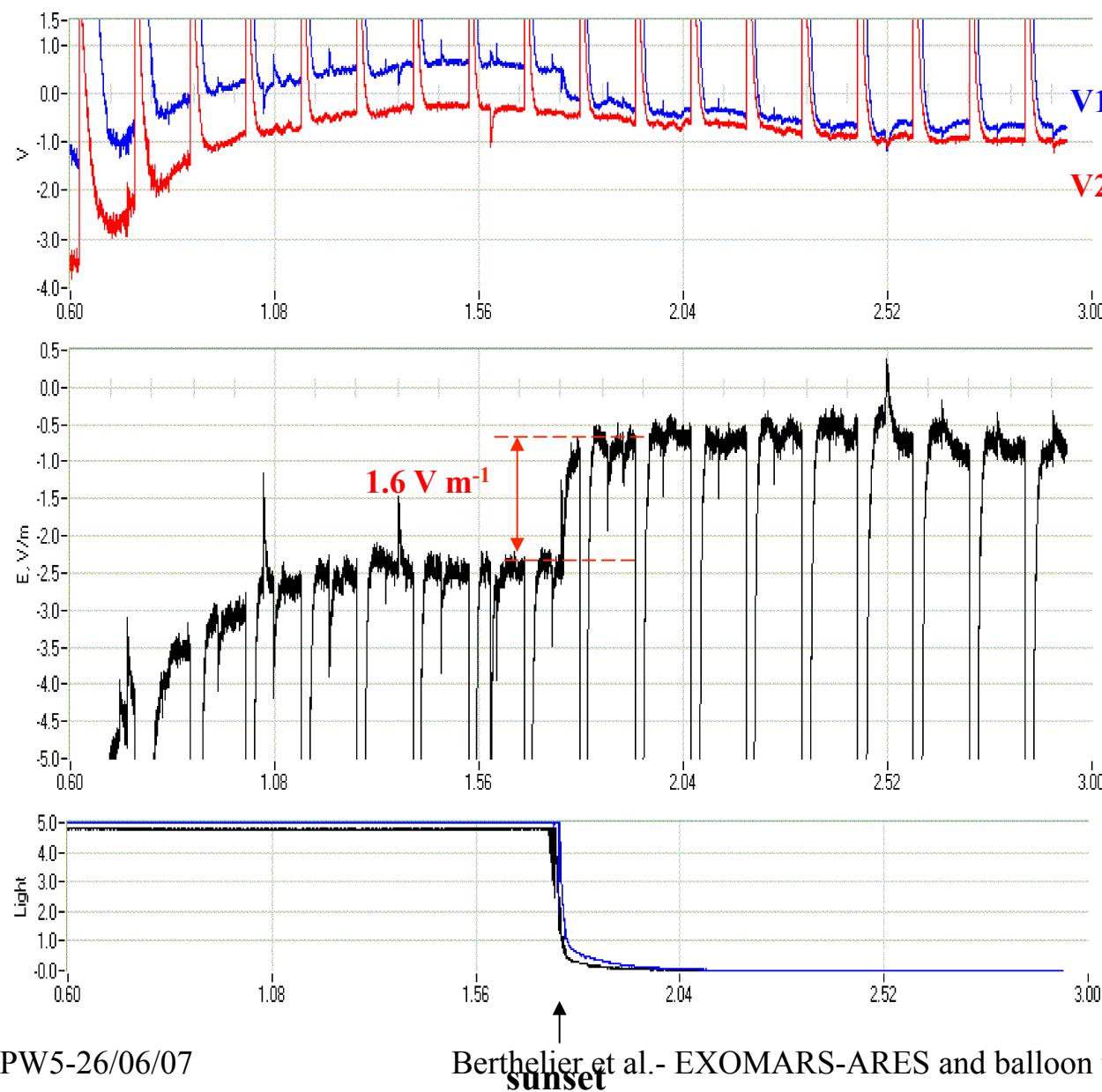


Electric field associated with charged clouds

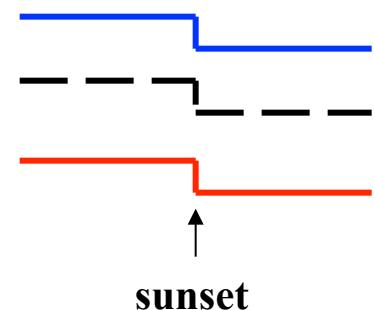


Balloon charging: $Q \sim \mu\text{C}$

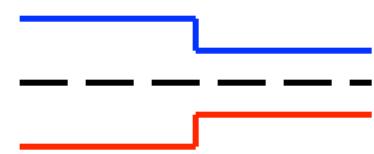
Drop of the electric field during the sunset



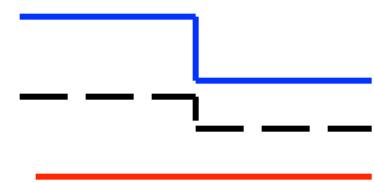
- decrease of V_{fl}



- decrease of \mathbb{E}

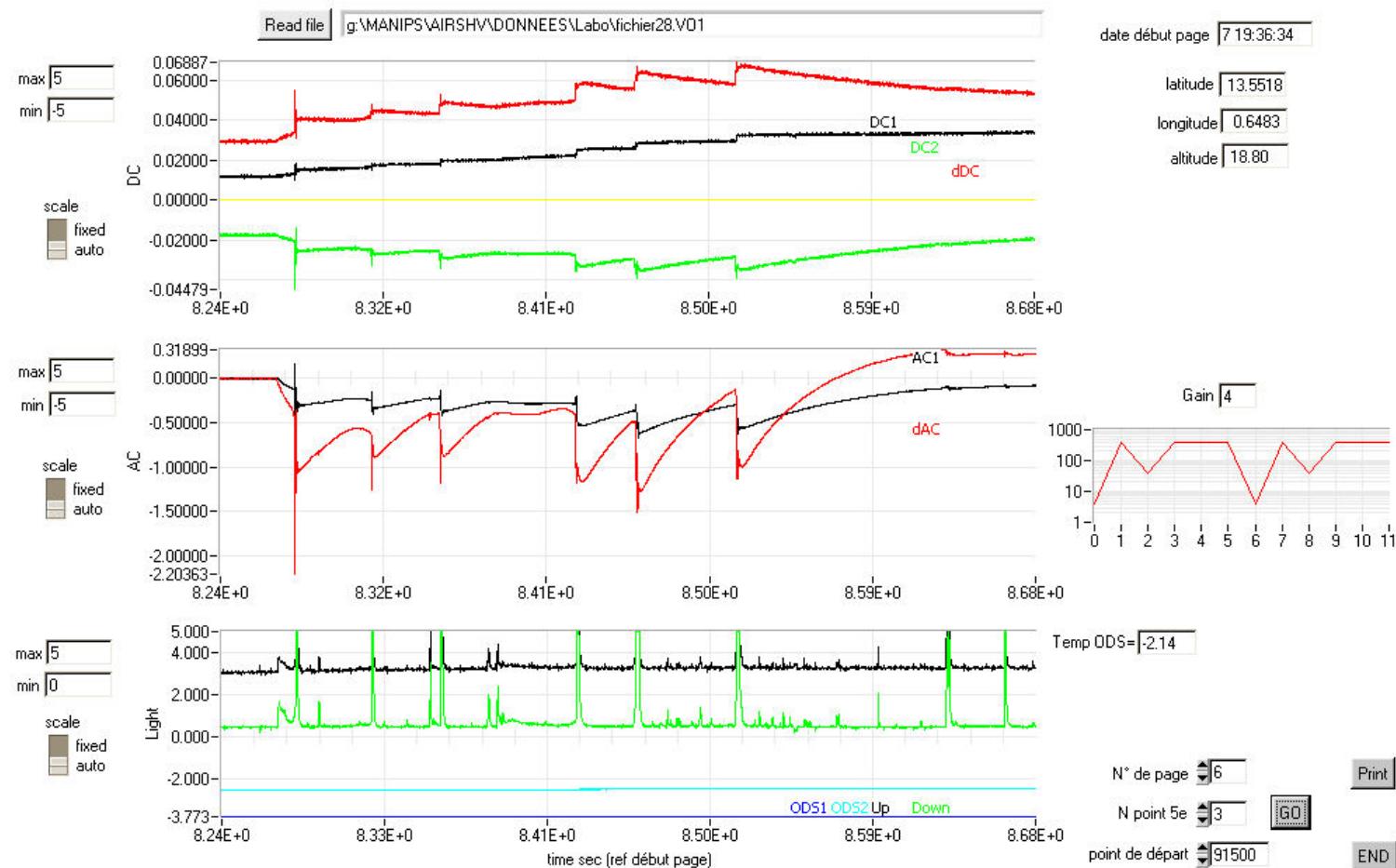


- decrease of V_{fl}
+ decrease of \mathbb{E}

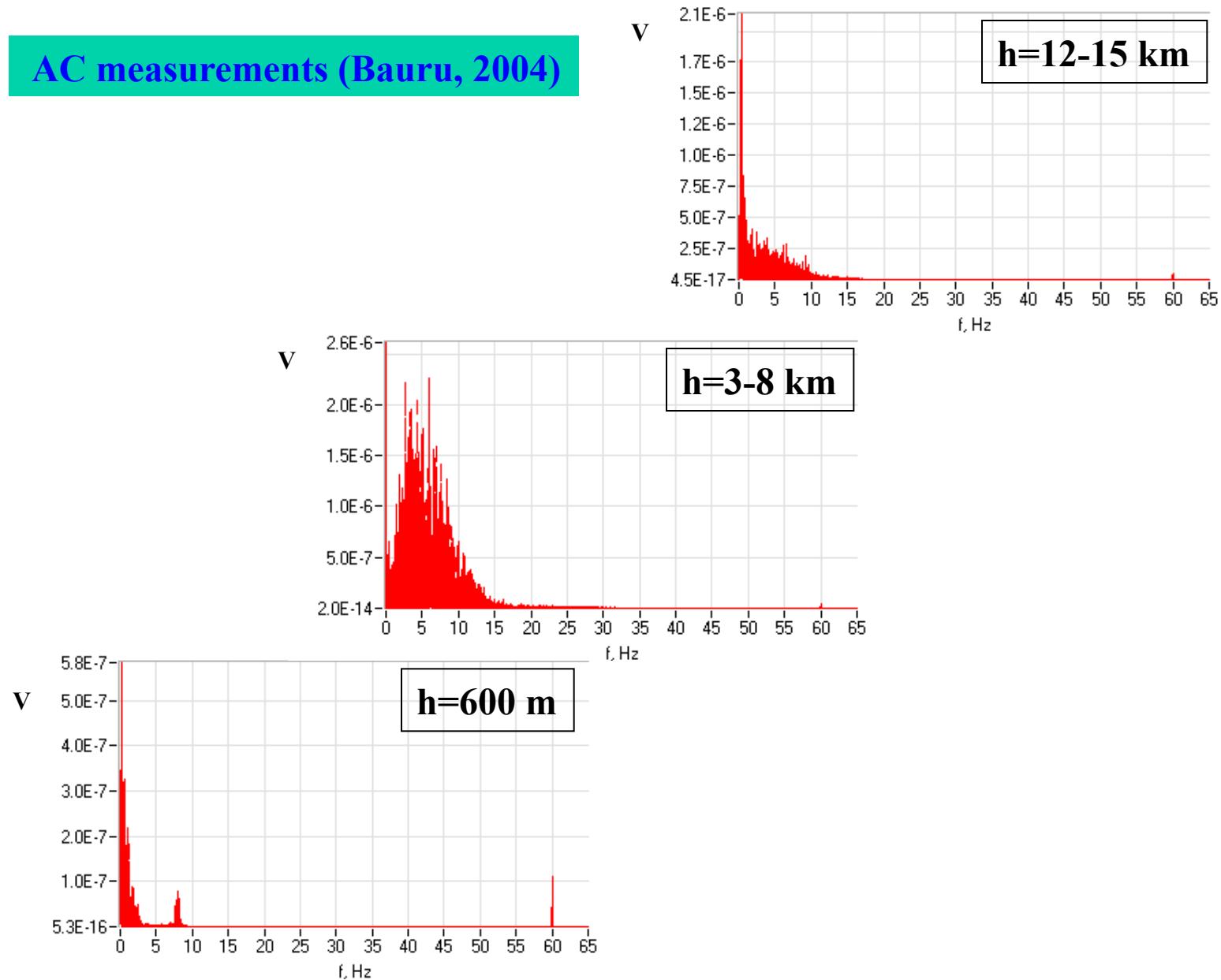


$$\Delta V_{fl} \mathbb{E} -0.3 \text{ V}$$

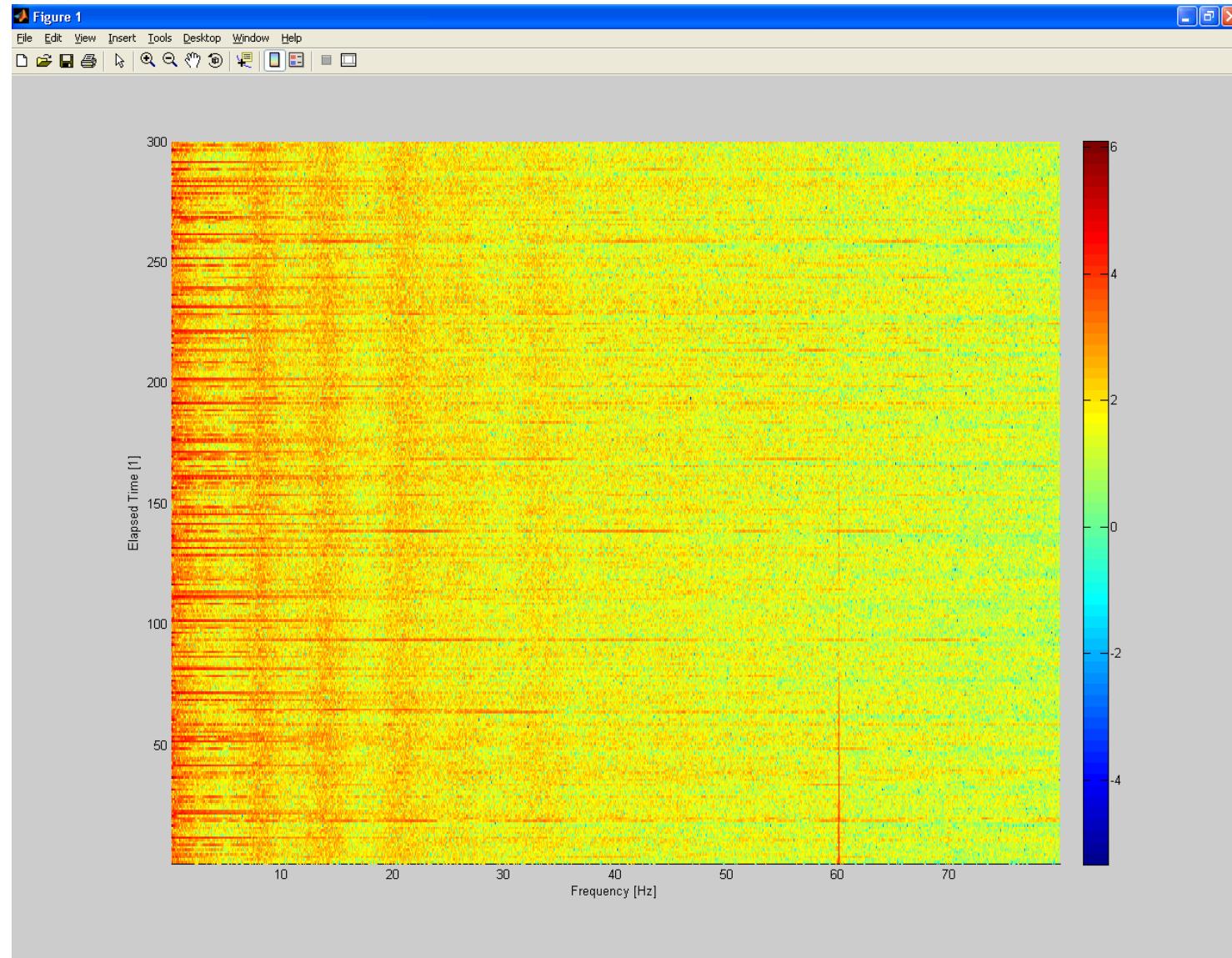
DC and AC Electric fields, AIRSHV, Niger – 2006 (with lightning activity)



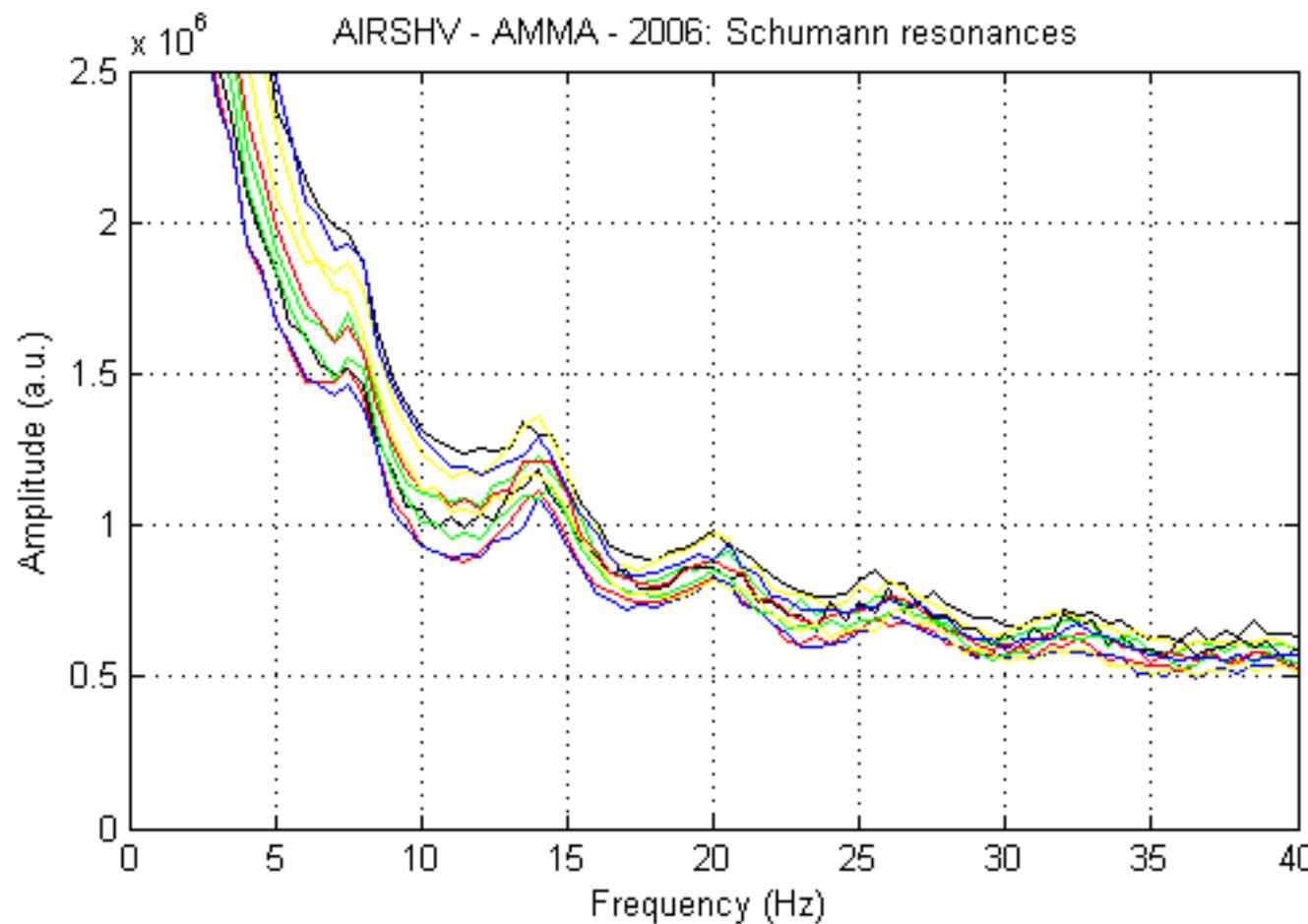
AC measurements (Bauru, 2004)



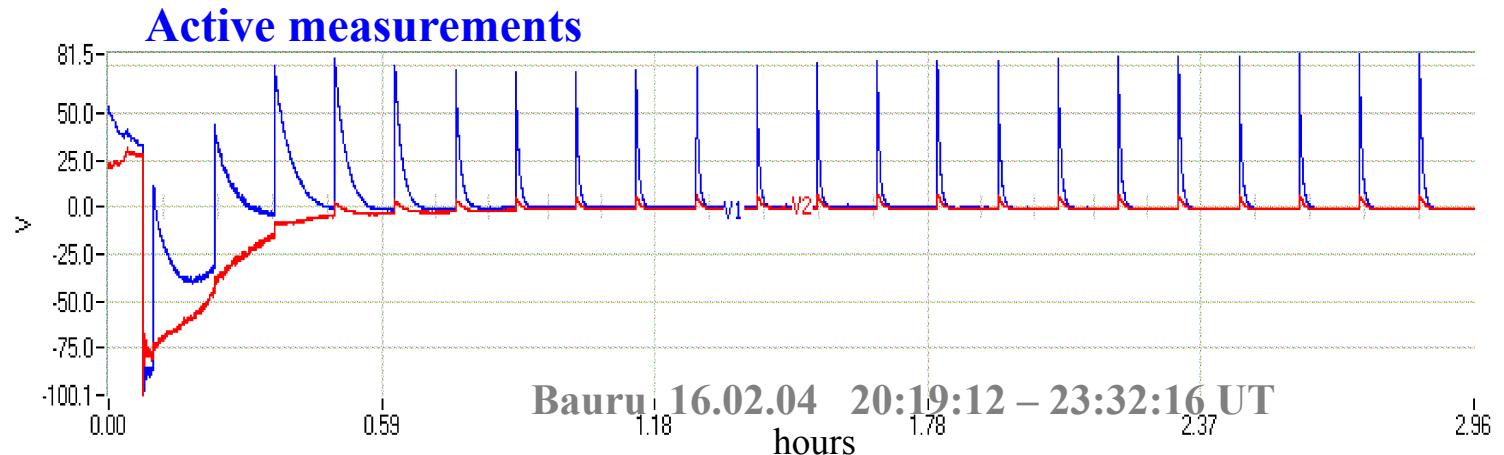
PEASMA- 2004: Schumann resonances



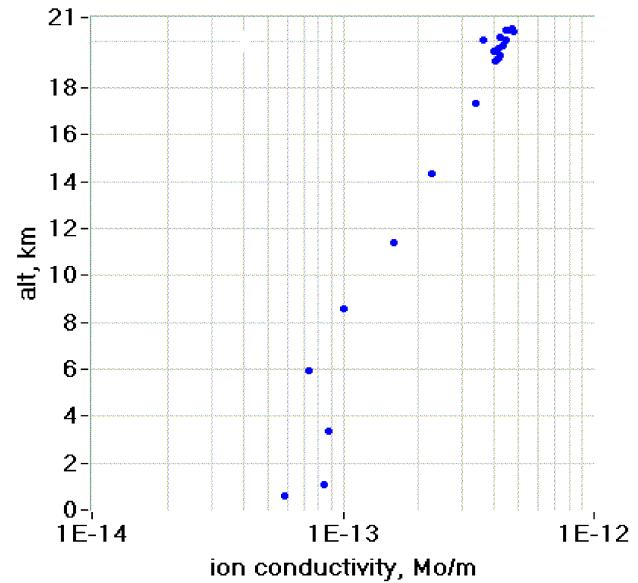
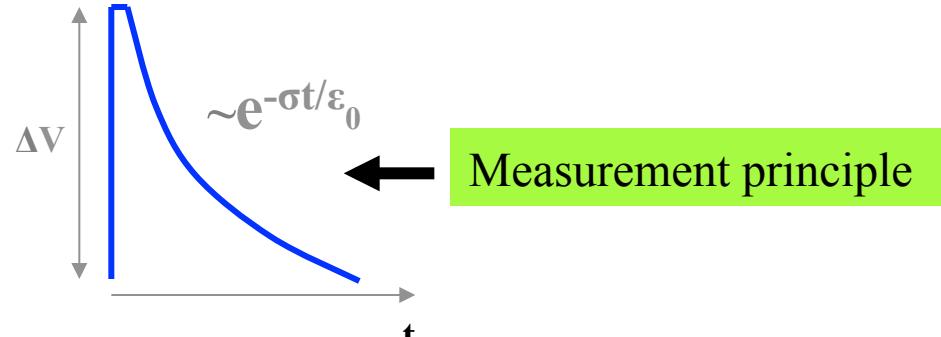
AIRSHV-AMMA- 2006: Schumann resonances



Conductivity Measurements (Relaxation Probe)

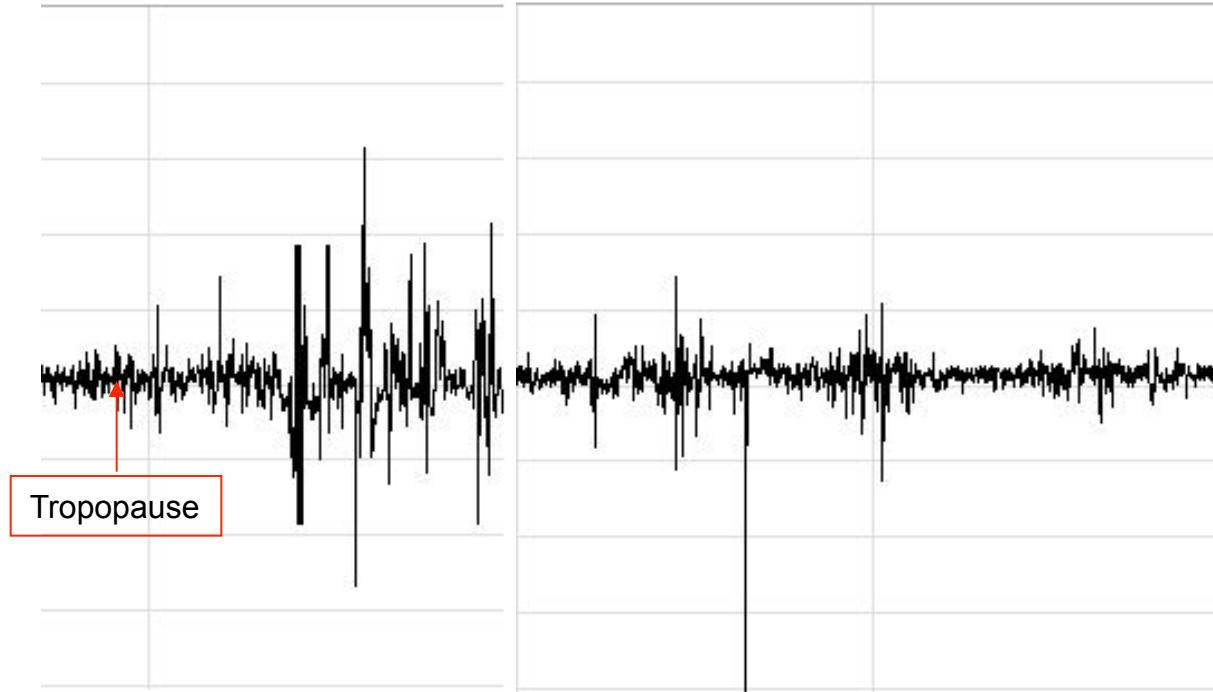


AIRS-HIBISCUS results



HVAIRS during AMMA, Niger, 2006

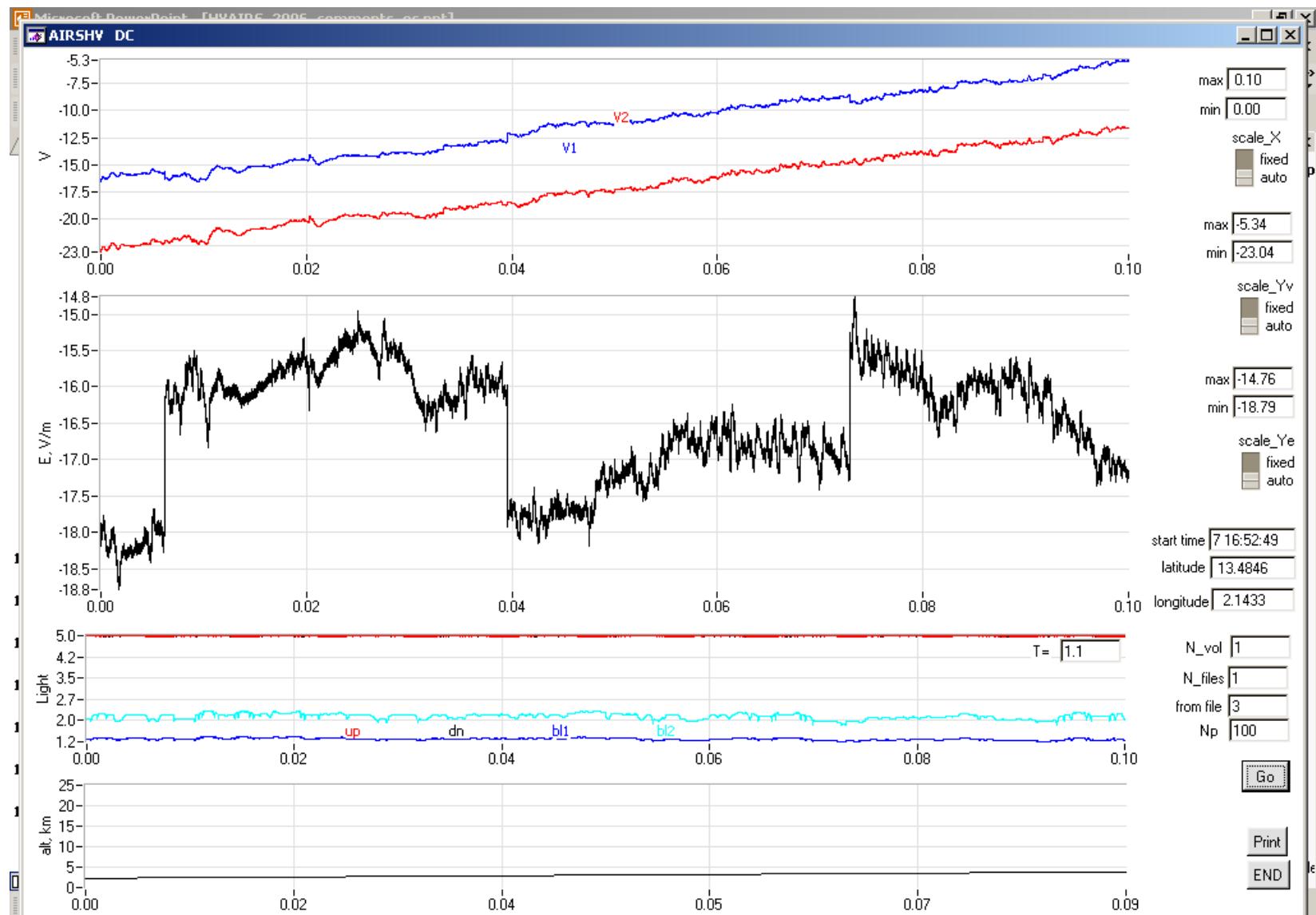
Electric field fluctuations associated with high altitude cirrus



Vertical electric field fluctuations observed by the high gain channel
from 15500m to 18000m during the ascent

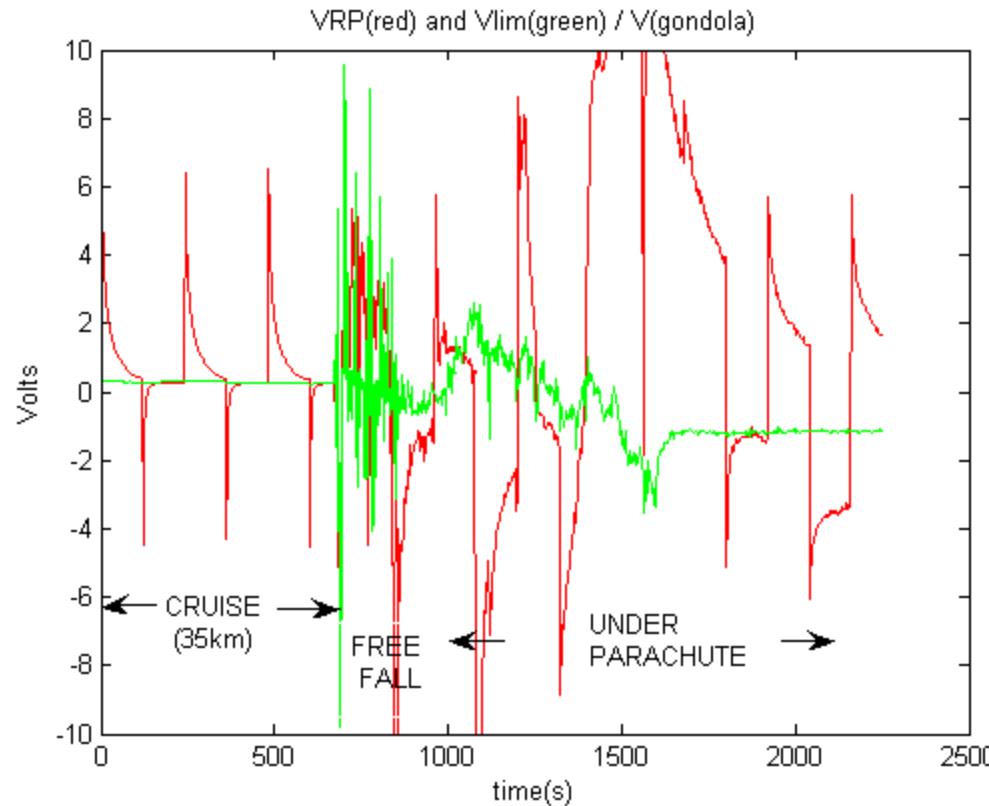
HVAIRS during AMMA, Niger, 2006

Electric field turbulence associated with clouds

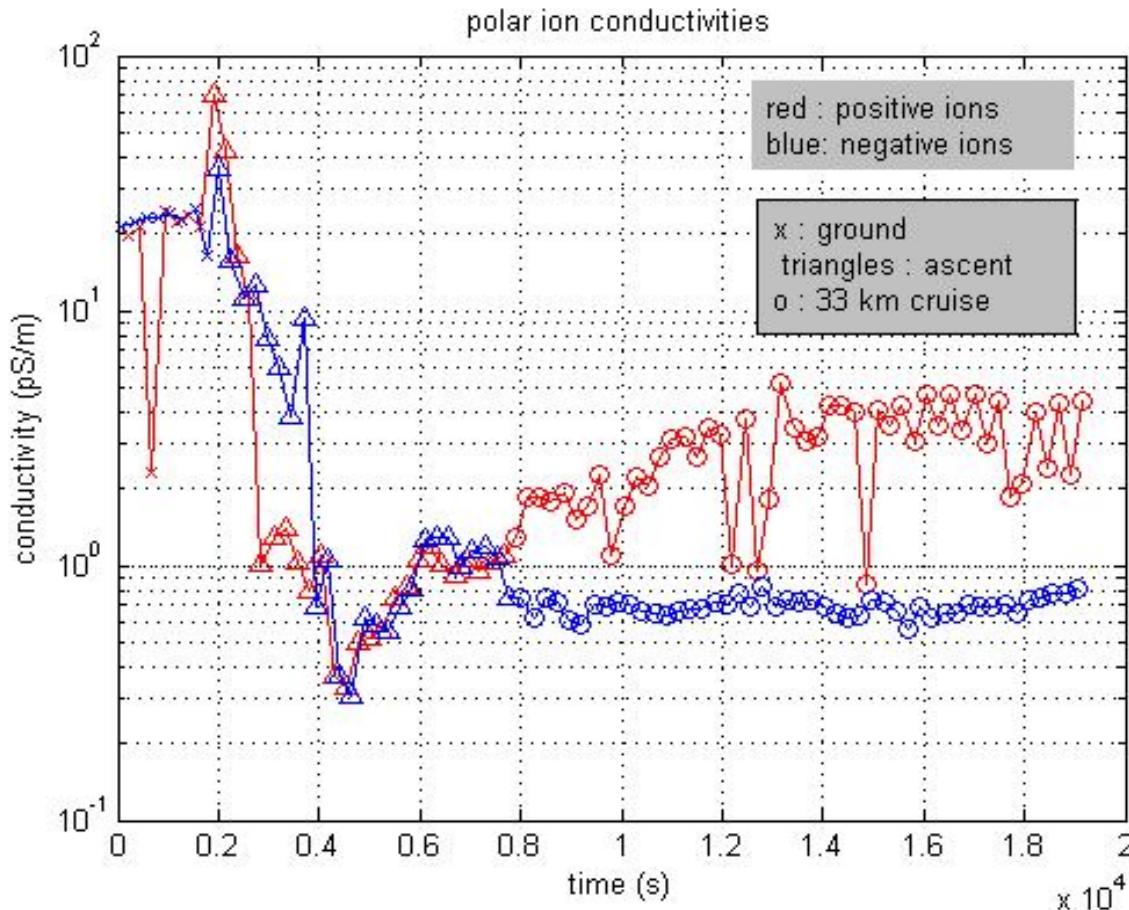


Relaxation and floating potential (Peasma, 2004)

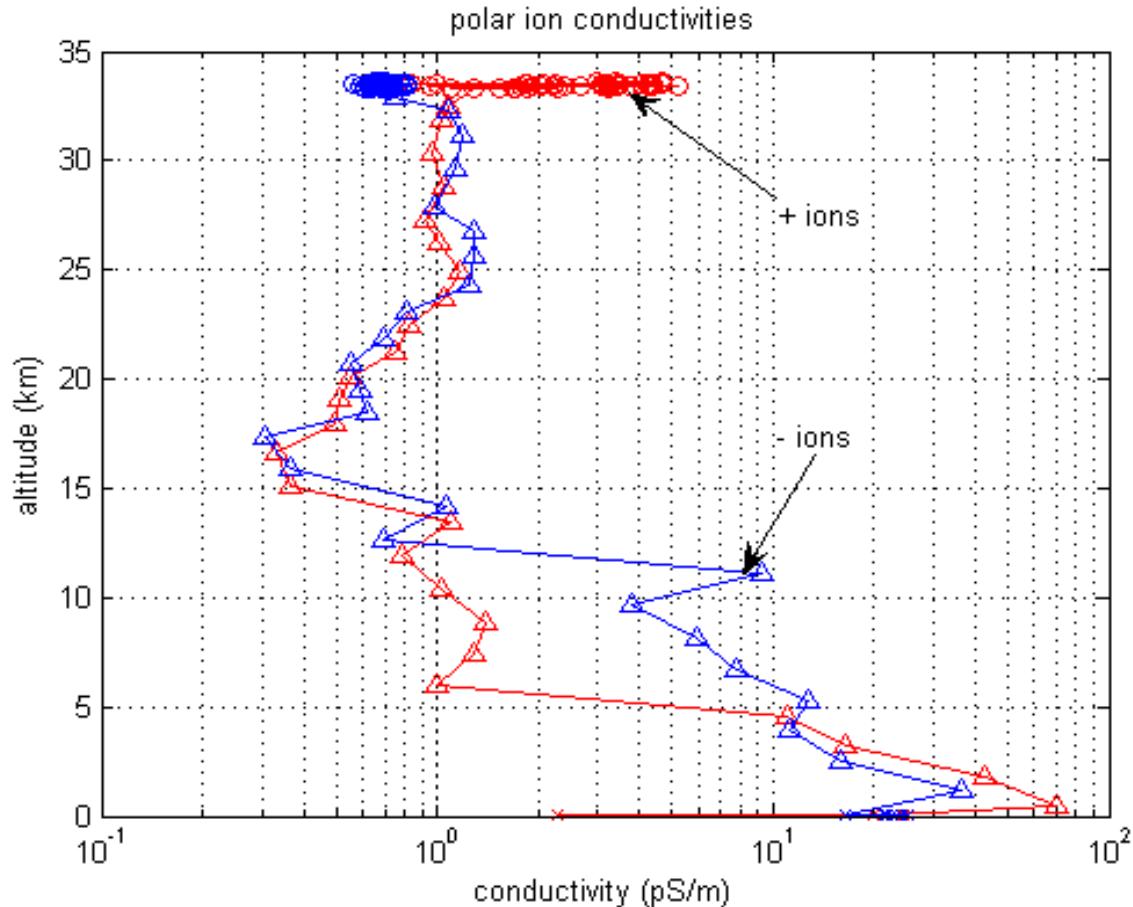
Comparison of RP electrode potential de RP with H9 potential (H9 symmetric / RP).
(Relaxation Probe independant from ARES but with same principle)



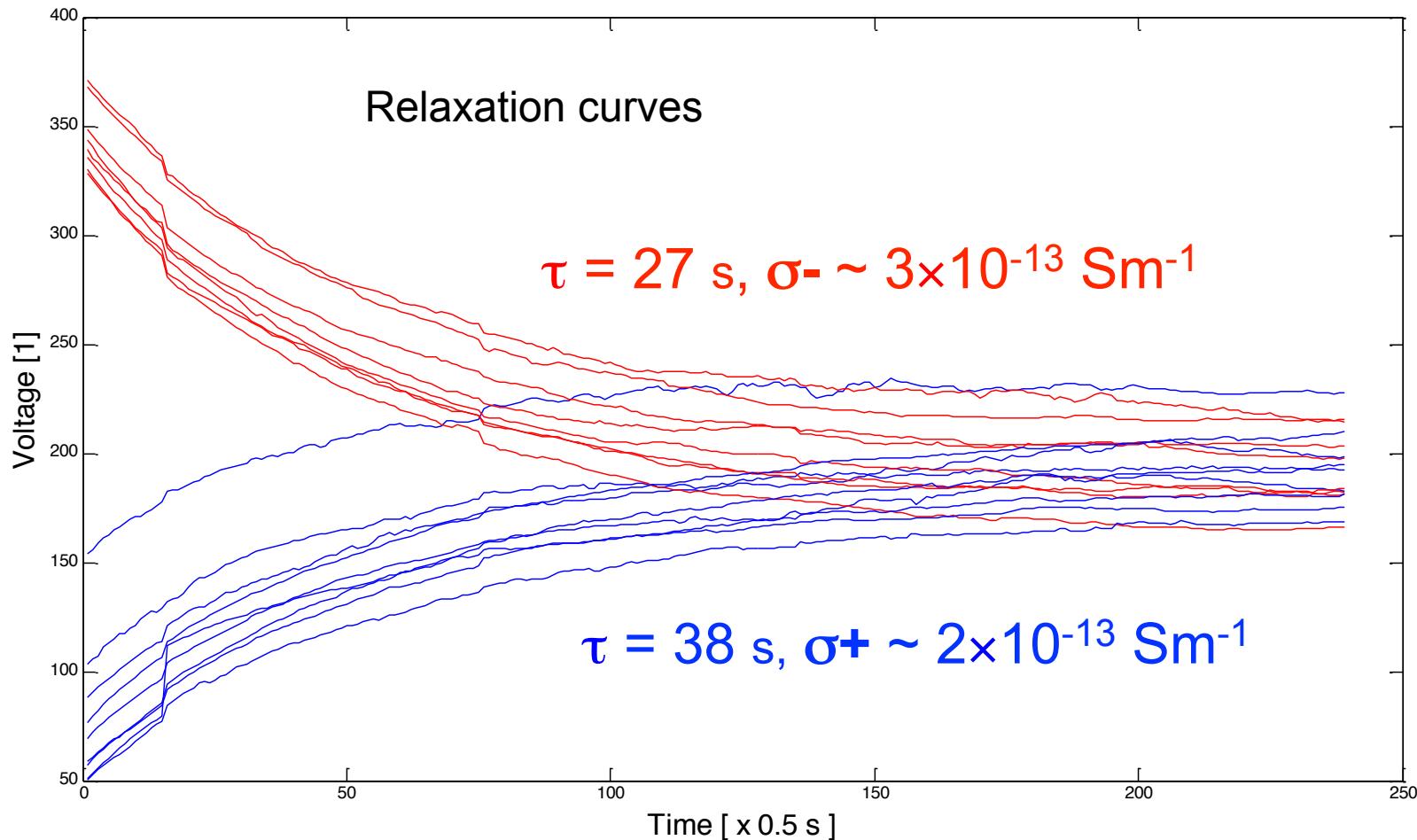
Conductivity measurements vs time (PEASMA, 2004)



Conductivity measurements vs altitude (PEASMA, 2004)



Positive and Negative Ion Conductivities at 22.5 ± 1 km (HVAIRS, 2006)



CONCLUSIONS

- Improvement of the instrument from ‘Netlander’ version to ‘Exomars-GEP’ version (including High Voltage capability)
- DC measurements (quiet field, cloud crossings, sunset effect,...)
- AC measurements (turbulence, Schumann resonances)
- Polar ionic conductivities

Points to test in a further balloon flight:

- High Voltage capability (flight in thunderstorm !)
- Integration with other (Meteo) sensors and influence of Solar Arrays